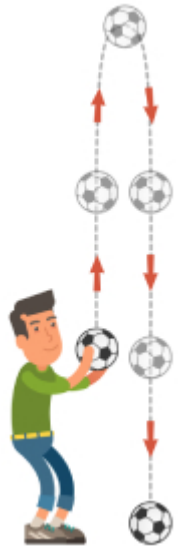
# Simulation

This demonstration is a simulation of throwing a ball straight up, plotting its height above the floor over time.[1]



The equation for that is:

$$h = h_0 + v_0 \times t + \frac{g \times t^2}{2}$$

where h is height above ground, $v_0$ is initial velocity, g is gravity, and t is time. In this simulation $h_0$ is 0, so ball is thrown up from floor. The equation is valid from throw until ball hits the floor. When the ball hits the floor, it will bounce up with less velocity than it hit the floor with. How much velocity is lost is determined by the ball and floor characteristics. This is called the coefficient of restitution which is a dimensionless number between 0 and 1. Golf ball on steel is 0.89, softball 0.44.

Simulations have trade offs between accuracy, effort to create, and run time. This simulation ignores air effects such as drag slowing the ball down. It assumes a perfectly flat floor so the ball bounces straight up again. The coefficient of restitution for real materials will not be a constant but will vary some with impact velocity. To make the simulation run faster, the height is calculated at 10 equally spaced time intervals over each bounce, connecting the points with straight lines. You can see that, especially at the top of each bounce the curve isn't smooth.

To implement the simulation equation can be solved for h=0 to determine duration of each bounce which is:

$$\frac{-2 * v_0}{g}$$

New $v_0$ is then calculated by multiplying $v_0$ by coefficient of restitution and process repeated.

Mathematical simulations have been used for a long time. Before computers complex simulations would have been calculated by people called computers whose job was performing calculations by hand or with mechanical calculators. ENIAC, the first programmable electronic digital computer created in 1945, was made for the purpose of calculating artillery firing tables. The tables are calculated from more accurate motion simulations. Since it was reprogrammable it was used for many different purposes.

1 Graphic from https://www.proprofs.com/quiz-school/story.php?title=projectile-motion_1